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## Seasonal Yield and Nitrogen Content of Three Grasses Grown Alone and in Association with Each Other and with White Dutch Clover

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SEASONAL YIELD AND NITROGEN CONTENT OF THREE GRASSES  
GROWN ALONE AND IN ASSOCIATION WITH EACH OTHER  
AND WITH WHITE DUTCH CLOVER

by

Donald B. Wilson

A thesis submitted in partial fulfillment  
of the requirements for the degree

of

MASTER OF SCIENCE

in

Agronomy

UTAH STATE AGRICULTURAL COLLEGE  
Logan, Utah

1954

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Donald B. Wilson

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## INTRODUCTION

The chief aim of pasture research is to discover means of providing the largest possible amount of highly nutritious forage at the time the animal requires it. Throughout the grazing season animal herbage requirements are relatively constant, while herbage production from pastures usually is quite variable.

Several practices have been employed in an attempt to obtain more uniform seasonal production, and overcome periods of feed surplus and feed shortage during the grazing season. One such practice has been to seed pastures comprised of several species. This is based on the observation that forage species differ in their requirements, and make maximum growth at different times of the year. Thus, it has been suggested, if the correct combination of species is obtained, production will be uniform throughout the season. However, uniform production has not generally been realized, and most mixtures follow similar patterns of production, determined by factors other than species composition.

This observation, brings up the question of whether it has been correct to assume that each species would maintain its individual characteristics in a mixture. It seems reasonable that one species would affect the growth

habit of others with which it is associated.

In the work reported herein, a comparison was made of the seasonal growth and yield of 3 grass species when grown alone and when grown in mixtures. The mixtures included all combinations of the three species with each other, and with white Dutch clover. The total yields of the mixtures were also compared for seasonal yield fluctuations. Nitrogen determinations were made on most of the separated species. Some of the literature pertaining to problems involved in obtaining uniform seasonal production was reviewed.

The work was done at the Dominion Experimental Station, Lethbridge, Alberta, Canada, in 1952 and 1953.



## REVIEW OF LITERATURE

Sinclair said in 1885 (Annon. 1924) "From the spring until the end of autumn there is not a month but is the season of luxuriance of one or more grasses." Others have noticed this phenomenon, and it has seemed reasonable to combine several different species into one pasture mixture to obtain season-long pasture. Besides more uniform seasonal production, an increase in total yield has been expected from species associations. Woodman (1926) was one who considered that a requirement of good pasture was "many species in correct proportions with different periods of growth."

Braun-Blanquet (1932) pointed out that aerial and subterranean layering makes possible the co-existence of several differently adapted species, and permits maximum utilization of an area. Furthur, Weaver and Clements (1938) suggest that competition is greater between plants of the same species than between those of different species. Again this seems reasonable, particularly in the light of such evidence as that of Burton (1943) who noted that several species of southern grasses belonging to the same genus, had root systems concentrated at different depths in the soil.

Based on this theory, that many species in association

will use an area to better advantage, many complex pasture mixtures have been recommended. Many recommendations have included 8 or 10 species, and according to Harrison (1951), some as many as 20 species. Such mixtures have been called "shotgun mixtures".

Complex mixtures have not proved to be satisfactory, however, and usually in such mixtures, one or two species predominate in a short time. Henson and Hein (1941) found that Kentucky bluegrass dominated 8 different pasture mixtures after 2 years. The complex mixtures appeared to yield a little more in the first 2 years, but seasonal variations were not diminished. Williams (1950) and Davies et al (1953) noted that orchard grass soon dominated alfalfa grown in association with it. Roberts and Olsen (1942) and Aberg et al (1943) grew grass and legume species in association in different combinations, and noted little benefit from the association. In general, an increase in one species resulted in a decrease in another. Ahlgren and Aamodt (1939) found some difference in yield per plant when 4 species were grown in different combinations, but the differences were not great. Brown and Munsell (1947) found that alfalfa yielded more alone than when grown with any of three grasses, and Comstock and Law (1948) found that a mixture of orchardgrass, brome grass, and alfalfa did not yield more than brome grass and alfalfa or orchardgrass and alfalfa. McCloud and Mott (1953) noted an increase in total yield when two species were grown in association, but the more

aggressive of the two reduced the yield of the other.

Since Lyon and Bizell first noted in 1911, that a plant growing with a legume could use atmospheric nitrogen fixed by the legume, most recommended pasture mixtures have contained one or more legumes. Not only do legumes supply nitrogen for grasses, but they also tend to fill in the gap left by the slow growth of grasses in mid-summer (Mulder 1952). This leads to more uniform seasonal production, as Gardner et al. (1935) have observed. Other workers (Sprague and Garber 1950, Kennedy 1950, and Eby et al. 1950) have observed that defoliation before the grass becomes too tall, helps to maintain ladino or white clover in the sward. Such defoliation has also been credited with more uniform seasonal production (Sprague and Garber 1950, Peterson and Hagan 1953). It is possible, then, that the clover is largely responsible for more uniform seasonal production. However, Johnstone-Wallace (1937) in New York reported that when Kentucky bluegrass and white Dutch clover were grown together, there was greater fluctuation in seasonal production than when either was grown alone.

It is generally agreed that most pasture mixtures should have at least one legume, and much attention is now paid to methods of maintaining the legume in the sward (Rasmussen et al. 1952, Davies 1952, Hedin and Rebischung 1952). Nolte and Koch (1930) reported that clovers could not supply all the nitrogen requirements of the grass, but later work suggests that 40-50 percent legume in a pasture

will supply all the nitrogen the grass requires (Johnstone-Wallace 1937, Sears et al. 1948). The difficulty lies in maintaining the proper balance of legumes in the pasture. Blaser and Brady (1950), Brown and Munsell (1936), Pratt and Holdaway (1937, 1948), and many others have suggested that this is mostly a matter of supplying sufficient potassium and phosphorous for the clover, as well as for the grass, and good management, including timely defoliation of the grass.

There is some suggestion that the nitrogen requirements of the plant could be supplied by mineral fertilizer, instead of clover. However, in one experiment a total of 84 pounds of nitrogen in three equal applications during the season, did not increase the yield of Kentucky bluegrass as much as did seeding ladino clover with the grass (Brown and Munsell 1943). From another experiment, Pratt and Holdaway (1948) reported that pastures fertilized with phosphorous and potassium produced cheaper animal gains than pastures fertilized with nitrogen. It is possible that this was due, at least partly, to the greater proportion of clover in the phosphorous and potassium fertilized pastures. Sears (1950) reported that nitrogenous fertilizers were effective in increasing pasture yields only in the absence of clover, and clover was as effective as sheep manure. Chamblee et al. (1953) found some response to nitrogen on clover-containing pastures, but the responses were probably not economical. Therefore, associated legumes must be

regarded as an important source of nitrogen for pastures. This source cannot be disregarded, for the world supply of nitrogen fertilizer is critical at present as Raymond (1953) has pointed out.

Seasonal fluctuations in yield are sometimes regarded as unimportant, for it is a recognized practice to conserve excess pasturage as hay or silage. However, this is sometimes a laborious and costly procedure, and in addition, dry matter losses may be high. Sears and Goodall (1947) in New Zealand, have shown that dry matter losses may be 30-40 percent even under good conditions.

The effect of plant associations on the nutritive value of herbage is also important. The ability of a legume to increase the protein content of the grasses grown with it has been recognized (Lyon and Bizell 1911, Lipman 1912, Fergus 1935). Wagner and Wilkins (1947) noted some increase in protein content of orchard grass when grown with ladino clover, and a greater increase in the protein content of brome grass. They also noted that ladino clover was more effective than alfalfa in increasing the protein content of the grasses.

## METHOD OF PROCEDURE

Species used in the study were orchard grass (Dactylis glomerata L) (Lethbridge), smooth bromegrass (Bromus inermis Leyss) (northern commercial ), creeping red fescue (Festuca rubra L) (commercial), and white Dutch clover (Trifolium repens L) (commercial). The grasses were grown in single species cultures, and in all combinations with each other and white Dutch clover. Following are the mixtures seeded, and rates of seeding in pounds per acre:

1. Brome 15
2. Orchard 10
3. Creeping red fescue 12
4. Brome 15, white Dutch clover 3
5. Orchard 10, W.D. clover 3
6. C.R. fescue 12, W.D. clover 3
7. Brome 7.5, orchard 5, W.D. clover 3
8. Brome 7.5, C.R. fescue 6, W.D. clover 3
9. Orchard 5, C.R. fescue 6, W.D. clover 3
10. Brome 5, orchard 3.3, C.R. fescue 4, W.D. clover 3

Seeding was done on irrigated land at Lethbridge, on May 3, 1952. Seeds were drilled in 7-inch rows, to a depth of one-half inch, with a tractor drawn, multiple v-belt seeder, No companion crop was used. Plots are 9' x 28', and replicated 5 times in a randomized complete block design. There is no border between plots. Fall rye was seeded around the outside of the plot area for a distance of 6 feet on all sides.

The land was fallowed the year preceding establishment of the plots, and was in alfalfa for several years

before that. The soil is a very fine sandy loam. The entire plot area is level, with good sub-surface drainage.

Plots were irrigated lightly by sprinkler to help establish the plants, and after that irrigations were made 2 or 3 days after each cutting. Three inches of water were applied at each irrigation.

No fertilizer was applied in 1952. In May 1953, ammonium phosphate, 11-48-0, and ammonium nitrate, 33-0-0, were uniformly broadcast over the plot area. The rate was 50 pounds each, of N and  $P_2O_5$ , per acre.

Plots were harvested twice in 1952, and five times in 1953. The 1953 harvests were made on May 27th, June 30th, July 30th, September 4th, and October 5th. The intention had been to harvest when the average height of the grasses was 6 to 8 inches. However, weather conditions precluded the adherence to this plan, and only one harvest, the third, was made when the grass was approximately 8 inches high. The height of the grass was about 12 inches for the first and second harvests, 5 inches for the fourth, and 4 inches for the fifth. The fifth harvest was made much later than originally anticipated. It was possible only because of an unusually open fall.

Total yields were determined by cutting a 3 x 25-foot swath from the centre of each plot, after the plots had been trimmed to a uniform length of 25 feet. The mower used was an Allen, a sickle type, gasoline-powered mower. It was adjusted to cut at a height of approximately 2 inches. The

cut herbage was raked into a tarpaulin and weighed in the field to the nearest ounce. The remainder of the plot was then cut, raked off the plot, and discarded. From each plot, a sample of approximately 600 grams of herbage was placed in a paper bag, and taken to the laboratory for dry matter determination. Drying was done in an electric oven at 190 degrees Fahrenheit.

A second sample of approximately 300 grams was drawn for each plot from the herbage in the tarpaulin, and placed in a separate paper bag. This sample, for botanical analysis, was taken to the laboratory and placed in a refrigerator. As time permitted, these samples were hand separated into each of the species sown in that plot, and a weed fraction. The separated species were then oven dried, and the percentage of each calculated. The percentages were applied to the total plot yield, and the yield of each species in pounds per acre was calculated.

Data for each species were analyzed separately. Each of the grasses was present in 5 plots of each replicate. Thus, brome was grown alone, with clover, with orchard and clover, with red fescue and clover, and with orchard, red fescue, and clover. Yields of brome only, were considered under these five treatments. Orchard grass and red fescue yields were analyzed similarly. White Dutch clover occurred in 7 plots of each replicate.

As an aid in interpreting the results of the experiment, the data were summarized through use of the analysis



of variance technique. Because of large differences in yield from cut 1 to cut 5, the error variance was heterogeneous. Therefore, actual yields were converted to logarithms for purposes of statistical analysis. The conversion made the error variance more nearly homogeneous.

Orthogonal polynomials were used to isolate linear and quadratic seasonal trends of each species under different treatments. Variation in these linear and quadratic effects were tested for significance by means of an F test in the usual analysis of variance. A significant difference in linear trends means that the rate of decline of yield from cut 1 to cut 5 varied for the different treatments. A significant quadratic effect means that the curve-linear trends of yield were different under different treatments.

Total yields of each mixture were analyzed similarly. There were 10 treatments based on total yields.

The analysis to compare seasonal growth trends under different treatments is on 1953 yields only. The 1952 harvests provide information on the botanical composition of the mixtures before the experiment proper began. They also provide information on the early competition between these grasses.

Nitrogen determinations were made on separated species from the botanical samples. The Kjeldahl method, described by the Association of Official Agricultural Chemists (1950), was followed. Crude protein was calculated by multiplying Nitrogen x 6.25.

## RESULTS

The advanced stage of growth of the plants for the first 2 cuttings resulted in relatively high yields in the early part of the season. Subsequent cuttings gave considerably lower yields. Thus, the general trend was a decline in yield over the season as measured by the cuttings.

Inter-species competition resulted in botanical changes in the mixtures as the season advanced. The general effect was that the tall spring growth of orchard grass and brome-grass suppressed the low-growing species, creeping red fescue and clover, in the early part of the season. Table 1 records the botanical composition of the mixtures at each cutting.

Actual yields of individual species and mixtures are recorded in tables to follow. Since statistical analyses were made of logarithms, calculated least significant differences are not applicable to actual yields. Therefore, each yield table is accompanied by a table of total seasonal yields, and linear and quadratic effects, expressed in logarithms. These logarithms are relative only, because they are the sum of logarithms for 5 cuts. Least significant differences are given for comparing treatment effects. Tables of logarithms are designated "A".

Yields of brome-grass in the 5 mixtures in which it

Table 1. Botanical composition of pasture mixtures at Lethbridge in 1953. Percentage of each sown species and weeds. (Average of 5 replicates)

Mix. & Species	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5
1 Brome	97	95	93	87	84
Weeds	3	5	7	13	16
2 Orchard	100	98	94	89	86
Weeds	0	2	6	11	14
3 C.R.F.	96	88	76	70	74
Weeds	4	12	24	30	26
4 Brome	90	81	65	51	42
Clover	9	17	35	47	56
Weeds	1	2	0	2	2
5 Orchard	100	96	96	83	66
Clover	0	3	4	14	32
Weeds	0	1	0	3	2
6 C.R.F.	91	57	36	34	35
Clover	4	37	61	60	60
Weeds	5	6	3	6	5
7 Brome	20	13	7	19	11
Orchard	78	83	82	50	43
Clover	2	4	9	29	44
Weeds	0	0	2	2	2
8 Brome	91	64	60	47	30
C.R.F.	6	11	6	6	6
Clover	2	22	33	45	62
Weeds	1	3	1	2	2
9 Orchard	98	92	85	75	35
C.R.F.	1	3	2	1	6
Clover	1	3	12	20	56
Weeds	0	2	1	4	3
10 Brome	10	12	8	11	10
Orchard	87	79	80	60	50
C.R.F.	1	3	1	2	6
Clover	1	3	10	25	33
Weeds	1	3	1	2	1

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occurred are recorded in Table 2. Relative treatment yields and linear and quadratic effects are recorded as logarithms in Table 2A. Seasonal trends are depicted graphically in Figure 1. In comparison with brome grown alone, yields were significantly lower in mixtures 7 and 10. These were the mixtures that included orchard grass. Rate of decline of yield of bromegrass over the season was slower when it was in association with clover, and fescue and clover. This is shown by the smaller negative value of the linear effect in Table 2A. Quadratic trends were not significant.

Orchard grass yields and trends are recorded in Tables 3 and 3A, and seasonal trends are shown graphically in Figure 2. There were no real differences in total yield, nor linear nor quadratic trends under any of the 5 treatments.

Creeping red fescue yields and trends are recorded in Tables 4 and 4A, and seasonal trends are depicted graphically in Figure 3. Yield of fescue was greater when it was grown alone, than when in mixture with other grasses. Association with clover did not increase the yield significantly. Rate of decline in yield over the season was reduced when fescue was grown with clover. When other grass species were included in the association there was no reduction in the rate of decline of fescue yields.

White Dutch clover yields and trends are recorded in Tables 5 and 5A, and seasonal trends are depicted graphically in Figure 4. Yield of clover with one grass species can be compared with its yield in mixtures with that species.

Table 2. Yields of brome grass (lbs. of dry matter per acre) in different associations of species at Lethbridge in 1953. (Average of 5 replicates)

Grown with-	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Total
Brome	2702	1786	871	357	22	5738
Clover	2161	2084	776	667	110	5798
Orch. & Clover	282	291	47	96	5	721
C.R.F. & Clover	1779	1520	532	588	77	4496
Orch., C.R.F., & Clov.	358	300	75	74	5	812

Table 2A. Relative seasonal yields and trends (logarithms), of brome grass in different associations of species at Lethbridge, 1953

Grown with-	Yield	Linear trends	Quadratic trends
Brome	13.29	-5.06	-2.06
Clover	14.27	-3.22	-1.17
Orchard & Clover	8.69	-4.11	-1.89
C.R.F. & Clover	13.63	-3.36	-1.37
Orch., C.R.F., & Clov.	9.00	-4.18	-1.71
5% least sig. diff.	2.82	1.60	-

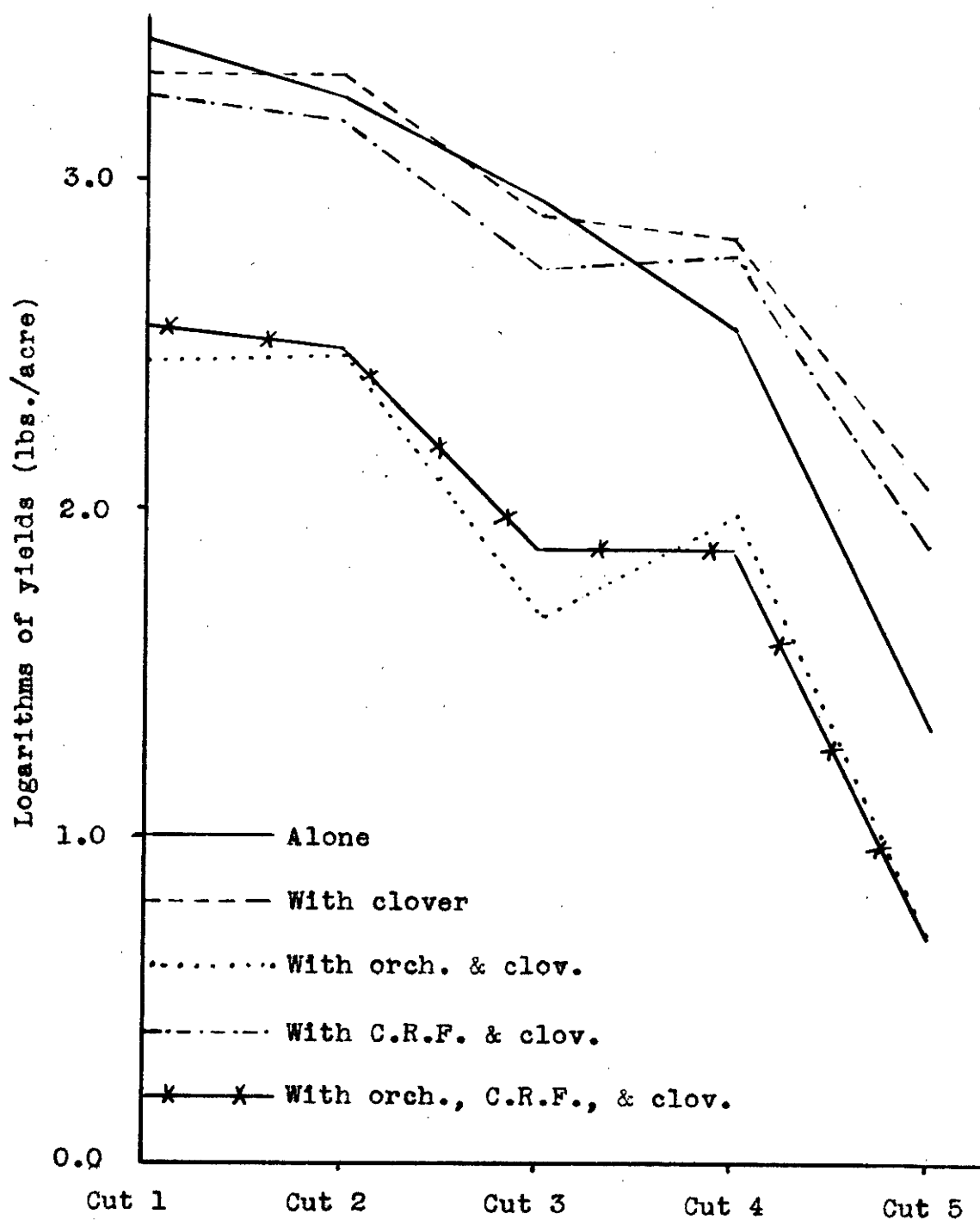


Figure 1. Seasonal trends of smooth brome grass yields in different associations of species at Lethbridge in 1953

Table 3. Yields of orchard grass (lbs. of dry matter per acre) in different associations of species at Lethbridge in 1953. (Average of 5 replicates)

Grown with-	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Total
Orchard	2076	1700	451	179	7	4413
Clover	2402	2149	731	461	41	5784
Brome & Clover	1862	1804	558	359	21	4604
C.R.F. & Clover	2129	1886	540	278	13	4846
Brome, C.R.F., & Cl.	1909	1890	720	482	35	5036

Table 3A. Relative seasonal yields and trends (logarithms) of orchard grass in different associations of species at Lethbridge, 1953

Grown with-	Yield	Linear trends	Quadratic trends
Orchard	12.10	-6.11	-2.54
Clover	13.50	-4.57	-1.72
Brome & Clover	12.69	-5.13	-2.08
C.R.F. & Clover	12.71	-5.42	-2.29
Brome, C.R.F., & Cl.	13.06	-4.90	-2.42

No significant differences

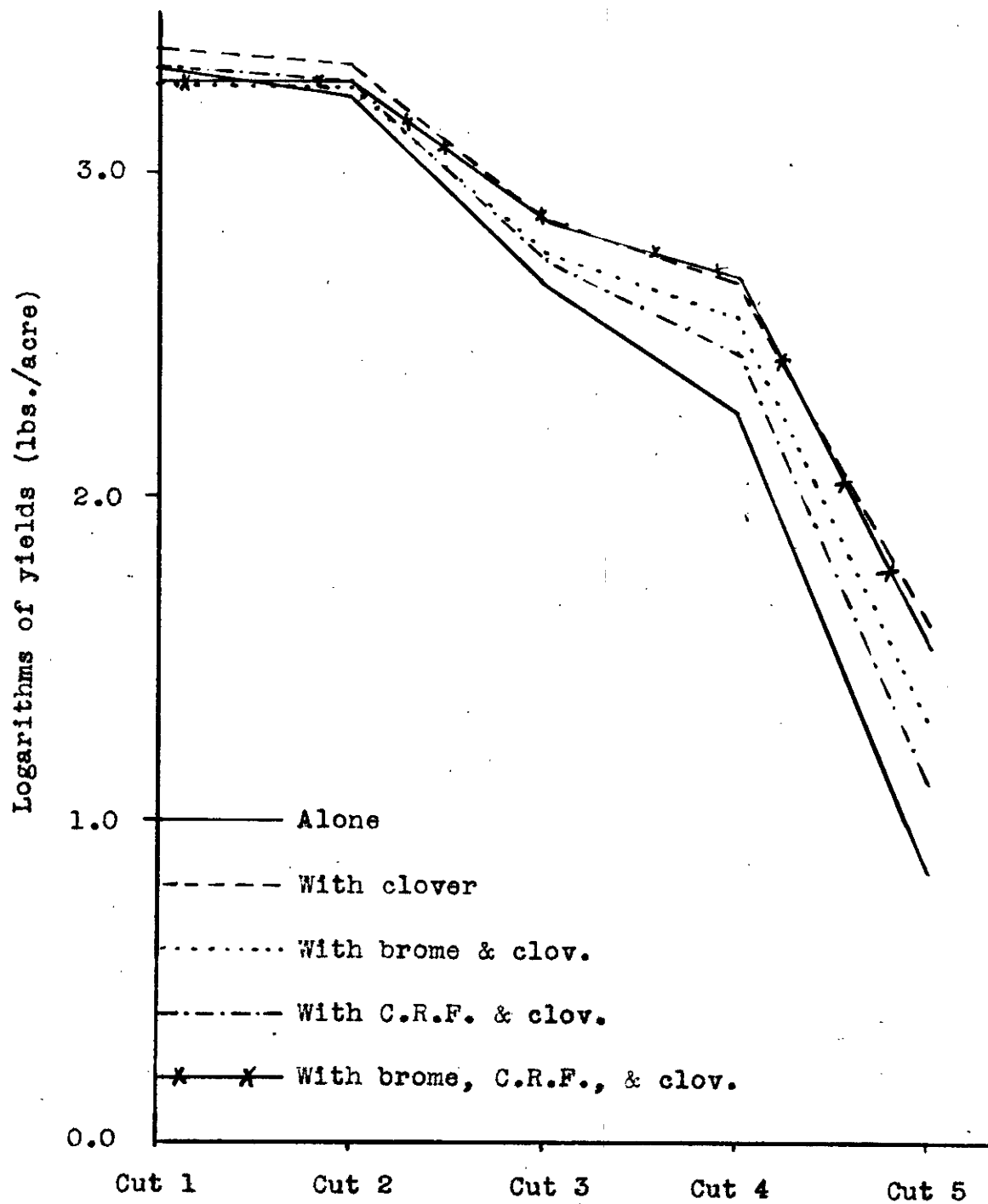


Figure 2. Seasonal trends of orchard grass yields in different associations of species at Lethbridge in 1953



Table 4. Yields of creeping red fescue (lbs. of dry matter per acre) in different associations of species at Lethbridge in 1953. (Average of 5 replicates)

Grown with-	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Total
C.R. fescue	2246	1310	355	197	98	4206
Clover	1676	1505	327	540	225	4273
Brome & Clover	327	265	59	49	15	715
Orch. & Clover	26	54	10	4	2	96
Brome, Orch., & Cl.	37	68	10	16	3	134

Table 4A. Relative seasonal yields and trends (logarithms) of creeping red fescue in different associations of species at Lethbridge in 1953

Grown with-	Yield	Linear trends	Quadratic trends
C.R. fescue	13.10	-3.87	-0.11
Clover	13.91	-2.28	0.13
Brome & Clover	9.29	-3.55	-0.24
Orch. & Clover	4.79	-3.63	-1.14
Brome, Orch., & Cl.	5.56	-3.18	-0.94
5% least sig. diff.	1.93	1.48	-

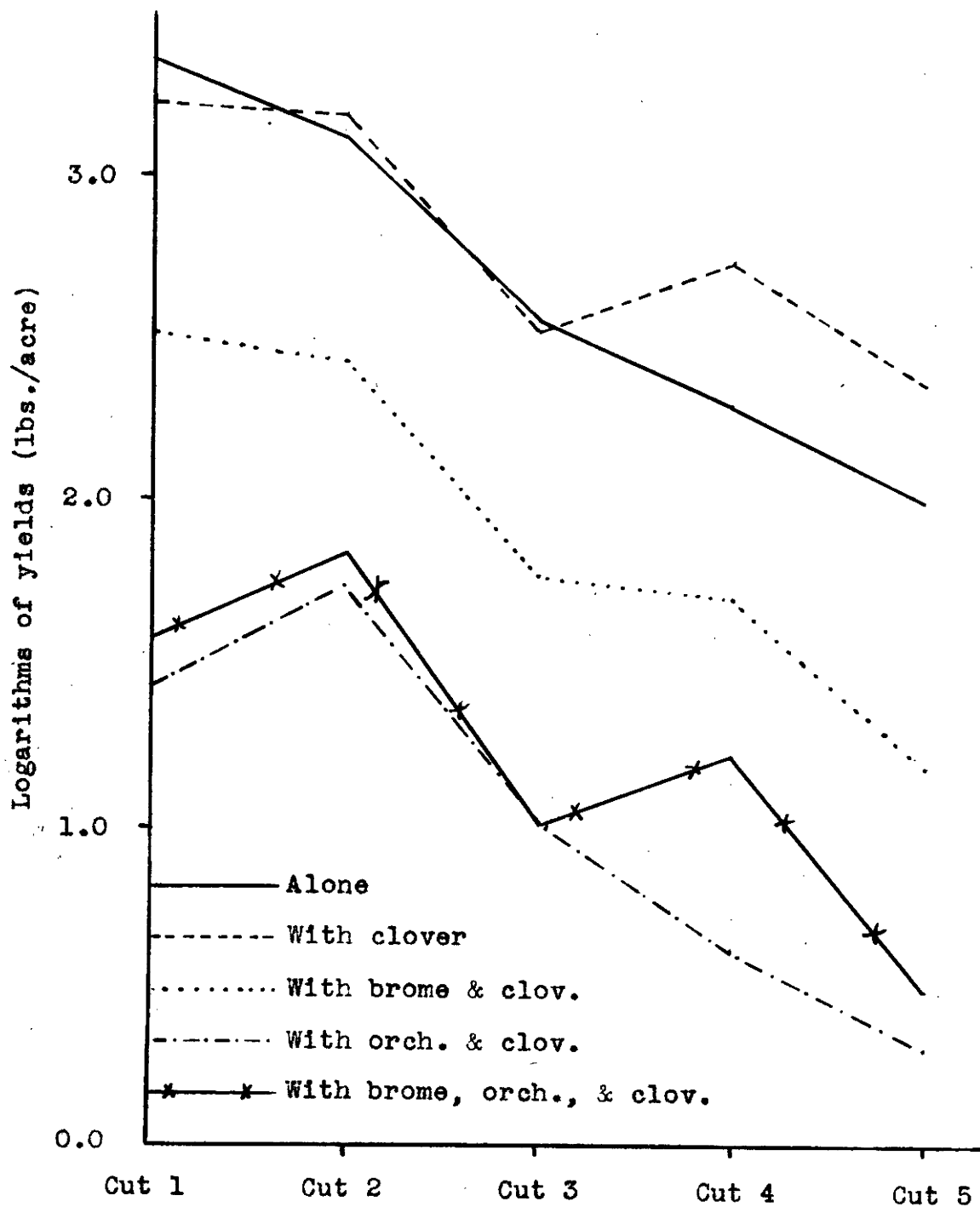


Figure 3. Seasonal trends of creeping red fescue yields in different associations of species at Lethbridge in 1953

Table 5. Yields of white Dutch clover (lbs. of dry matter per acre) in different associations of species at Lethbridge in 1953. (Average of 5 replicates)

Grown with-	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Total
Brome	161	430	407	548	146	1692
Orchard	5	71	22	45	18	161
C.R. fescue	182	964	575	946	367	3034
Brome & Orchard	20	72	47	135	15	289
Brome & C.R.F.	151	542	308	576	153	1730
Orchard & C.R.F.	10	71	62	73	18	234
Brome, Orch., & C.R.F.	37	146	70	137	18	408

Table 5A. Relative seasonal yields and trends (logarithms) of white Dutch clover in different associations of species at Lethbridge in 1953

Grown with-	Yield	Linear trends	Quadratic trends
Brome	12.16	0.07	-1.90
Orchard	5.56	0.29	-2.91
C.R. fescue	13.42	0.74	-1.90
Brome & Orchard	7.74	0.62	-2.22
Brome & C.R. fescue	12.08	0.16	-1.80
Orch. & C.R. fescue	6.84	0.46	-3.16
Brome, Orch., & C.R.F.	7.85	-0.20	-2.50
5% least sig. diff.	3.90	-	-

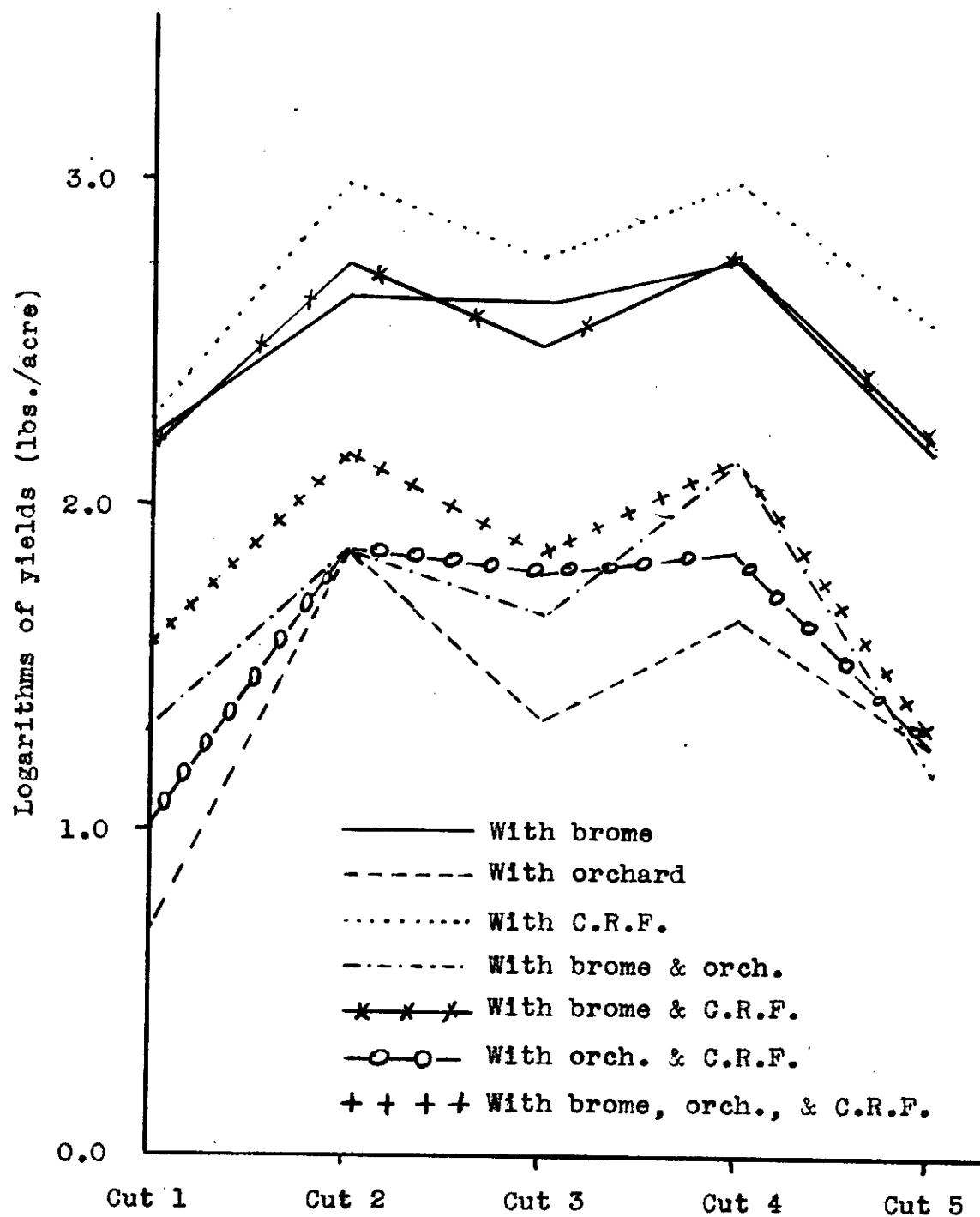


Figure 4. Seasonal trends of white Dutch clover yields in different associations of species at Lethbridge in 1953

In such a comparison, all data fall into 2 groups. In all mixtures including orchard grass, yields of clover were significantly lower than in mixtures not including orchard grass. There were no differences in linear nor quadratic trends.

Total yields and trends of the mixtures are recorded in Tables 6 and 6A, and trends are depicted graphically in Figures 5 to 8. Total yield of each mixture and contribution of each species, is shown graphically in Figure 9. Bromeclover and fescue-clover mixtures yielded more than these grasses grown alone, but the orchard-clover mixture did not yield significantly more than orchard alone. Mixtures of 2 or 3 grasses did not yield more than one grass with clover. Addition of orchard grass to bromeclover mixtures resulted in a decreased yield. Rate of decline in yield over the season was slower for mixtures of one grass and clover, than for the grass grown alone. Incorporation of another grass into the mixture did not reduce the rate of decline further. The only real quadratic effect was that the rate of decline in yield of creeping red fescue alone, decreased as the season advanced.

Percentage crude protein was determined for individual species in the first 4 cuts when sufficient material was available. Some of the botanical samples were not large enough to provide sufficient clover or creeping red fescue for a determination. This lack of material was not realized until the botanical separations were made. It was then

Table 6. Total yields of pasture mixtures (lbs. of dry matter per acre) at Lethbridge in 1953. (Average of 5 replicates)

Mixture	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Total
1	2776	1886	921	404	91	6078
2	2156	1736	471	199	55	4617
3	2324	1481	468	285	254	4812
4	2340	2552	1187	1047	388	7714
5	2408	2239	753	517	111	6028
6	1912	2622	932	1583	834	7883
7	2164	2199	662	606	93	5714
8	2328	2363	904	1062	372	7229
9	2164	2044	617	366	88	5279
10	2360	2420	877	716	132	6505

Table 6A. Relative yields and trends of pasture mixtures (logarithms) at Lethbridge in 1953

Mixture	Yield	Linear trends	Quadratic trends
1	14.11	-3.69	-0.88
2	13.16	-4.19	-0.73
3	13.96	-2.79	+0.45
4	15.48	-1.92	-0.75
5	14.11	-3.40	-0.81
6	15.76	-0.96	-0.18
7	14.13	-3.36	-1.11
8	15.31	-1.92	-0.58
9	13.82	-3.61	-0.85
10	14.49	-3.19	-1.06
5% least sig. diff.	1.30	0.77	0.88

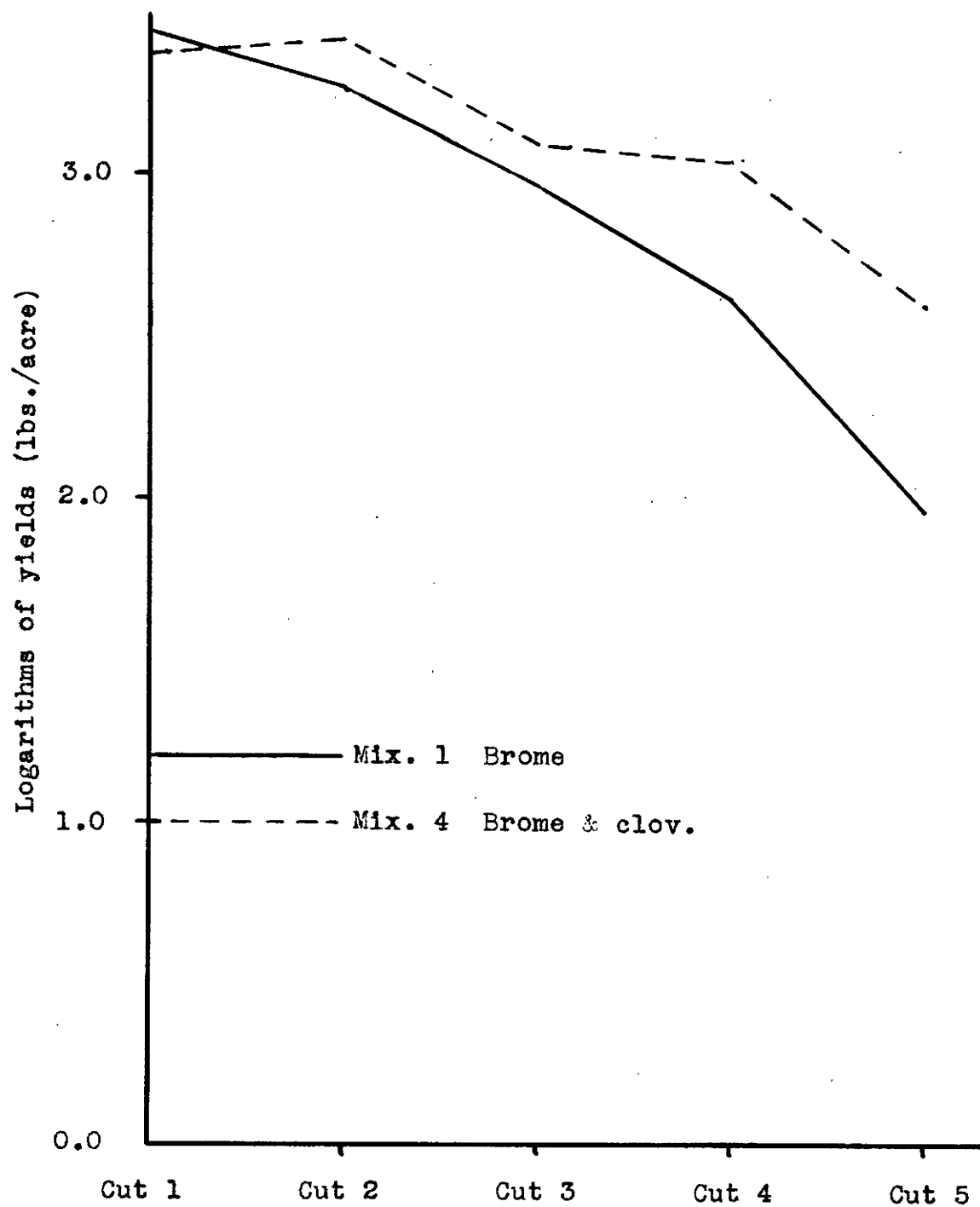


Figure 5. Seasonal trends of yields of mixtures 1 and 4 at Lethbridge in 1953

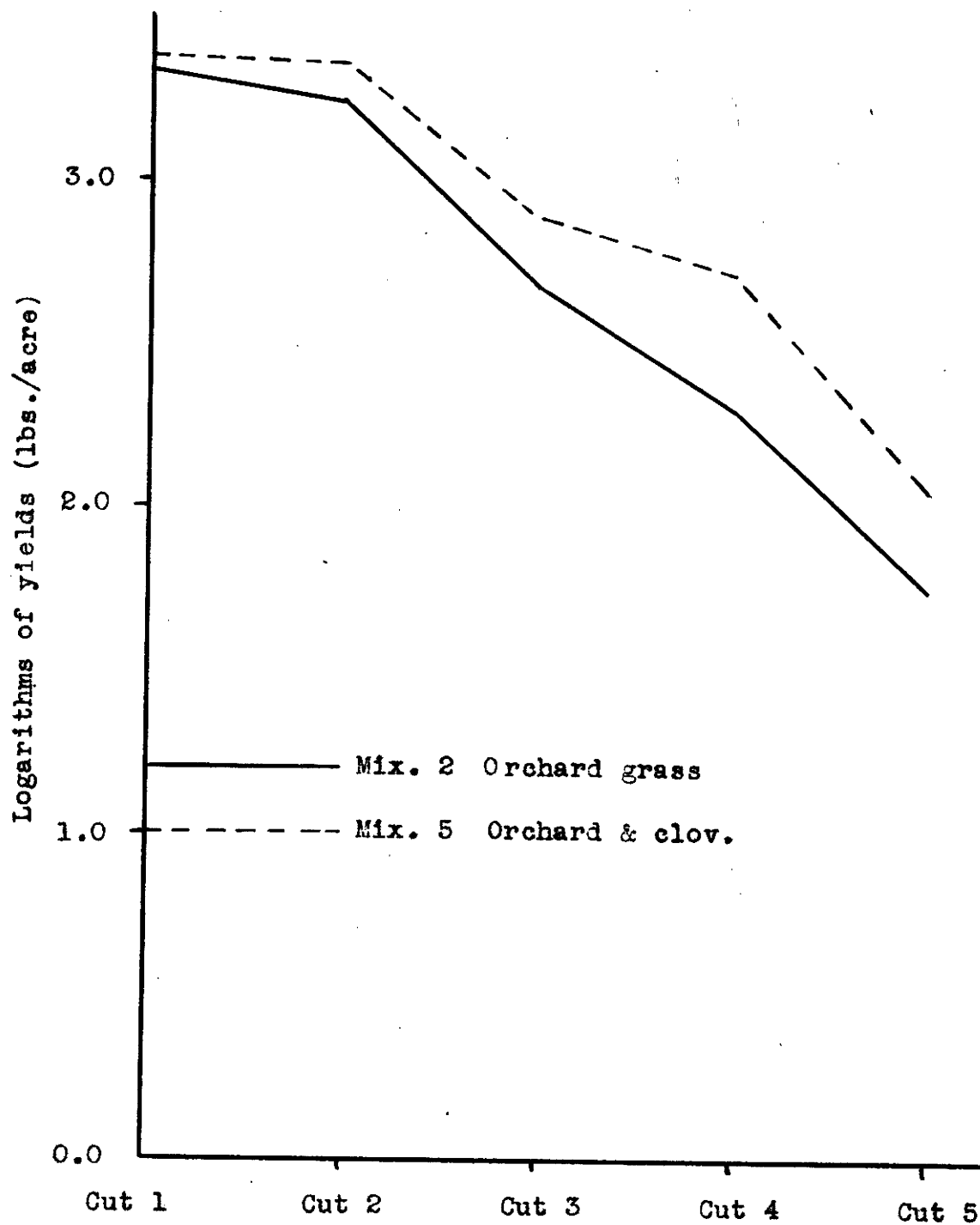


Figure 6. Seasonal trends of yields of mixtures 2 and 5 at Lethbridge in 1953



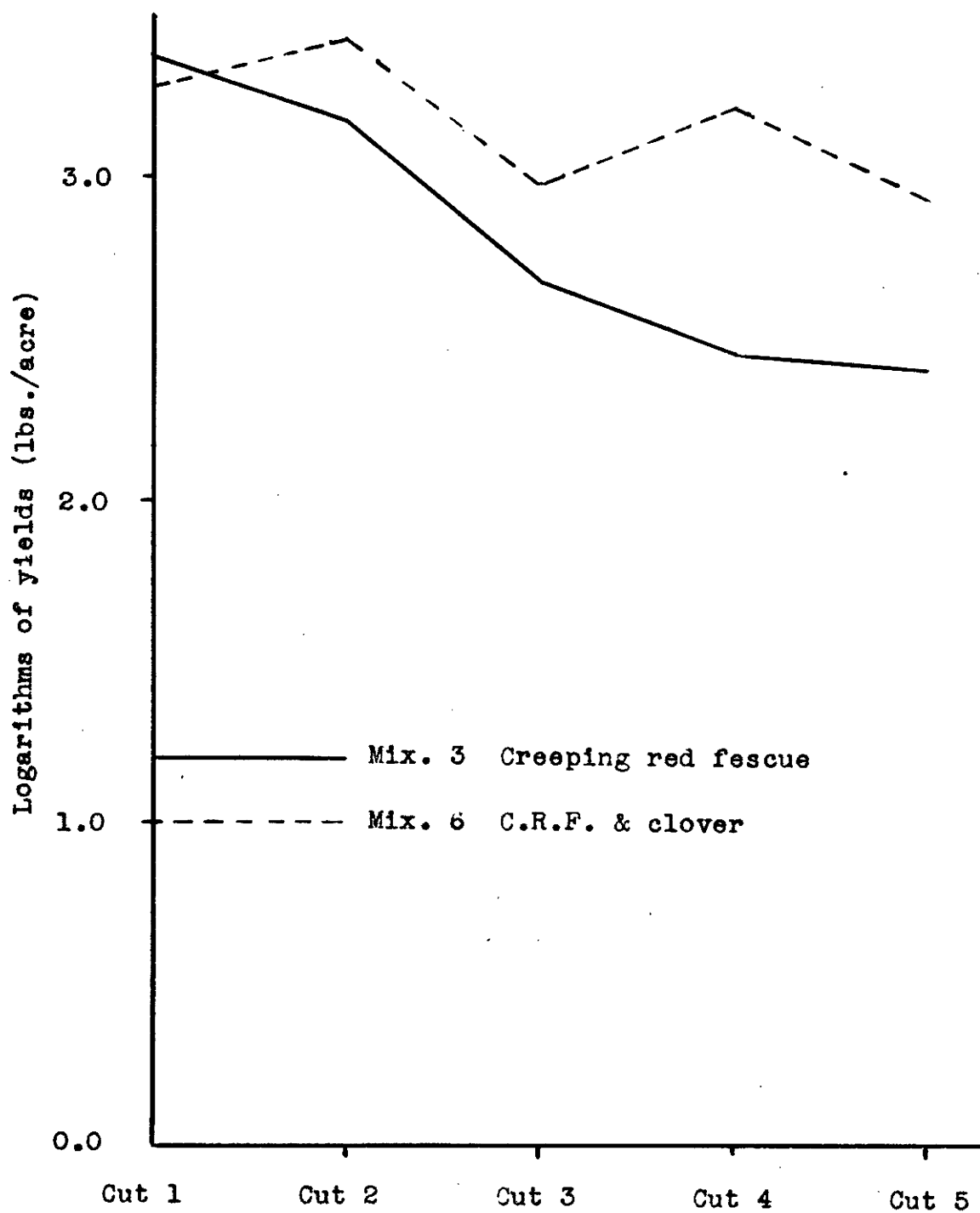


Figure 7. Seasonal trends of yields of mixtures 3 and 6 at Lethbridge in 1953

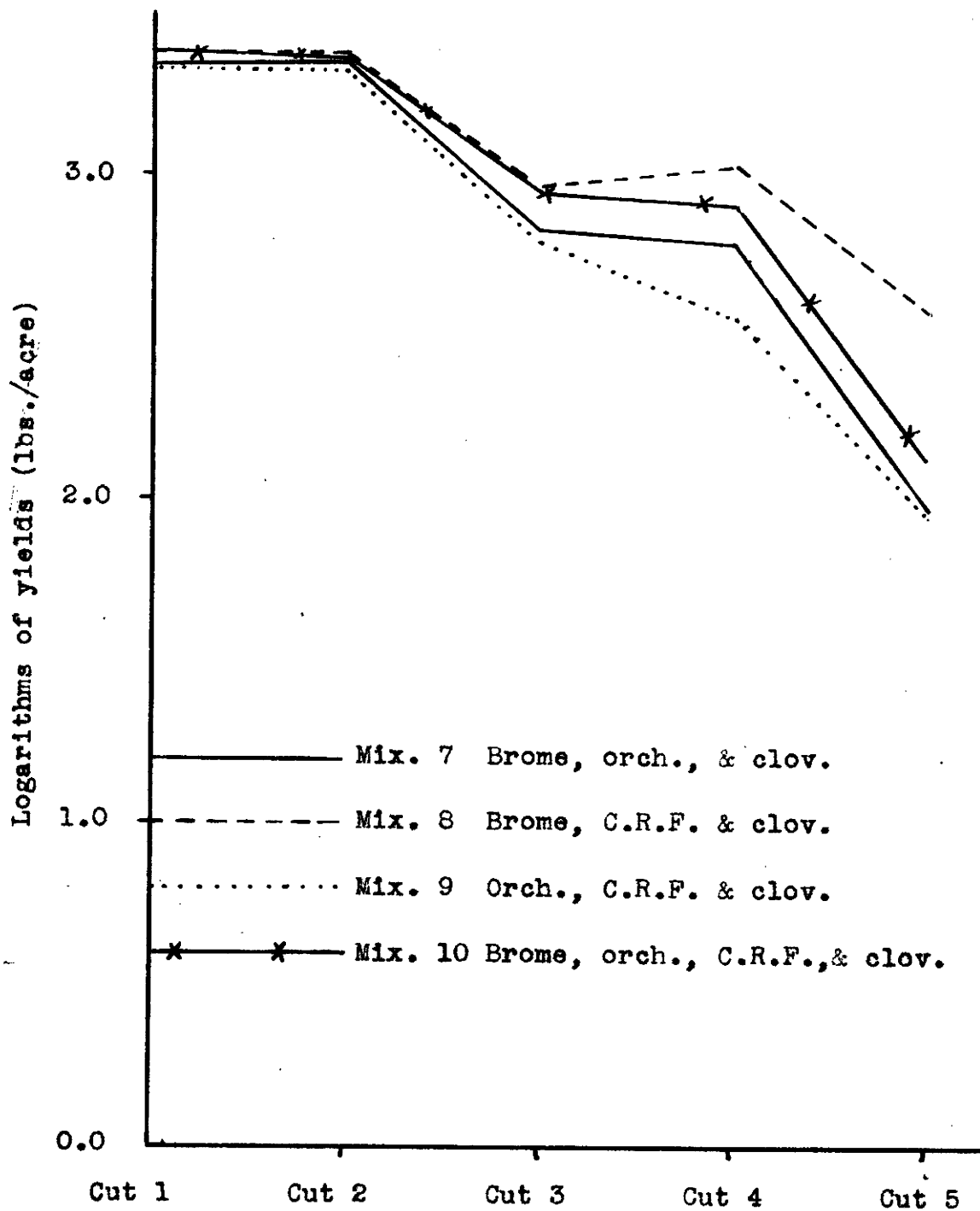


Figure 8. Seasonal trends of yields of mixtures 7, 8, 9, & 10 at Lethbridge in 1953

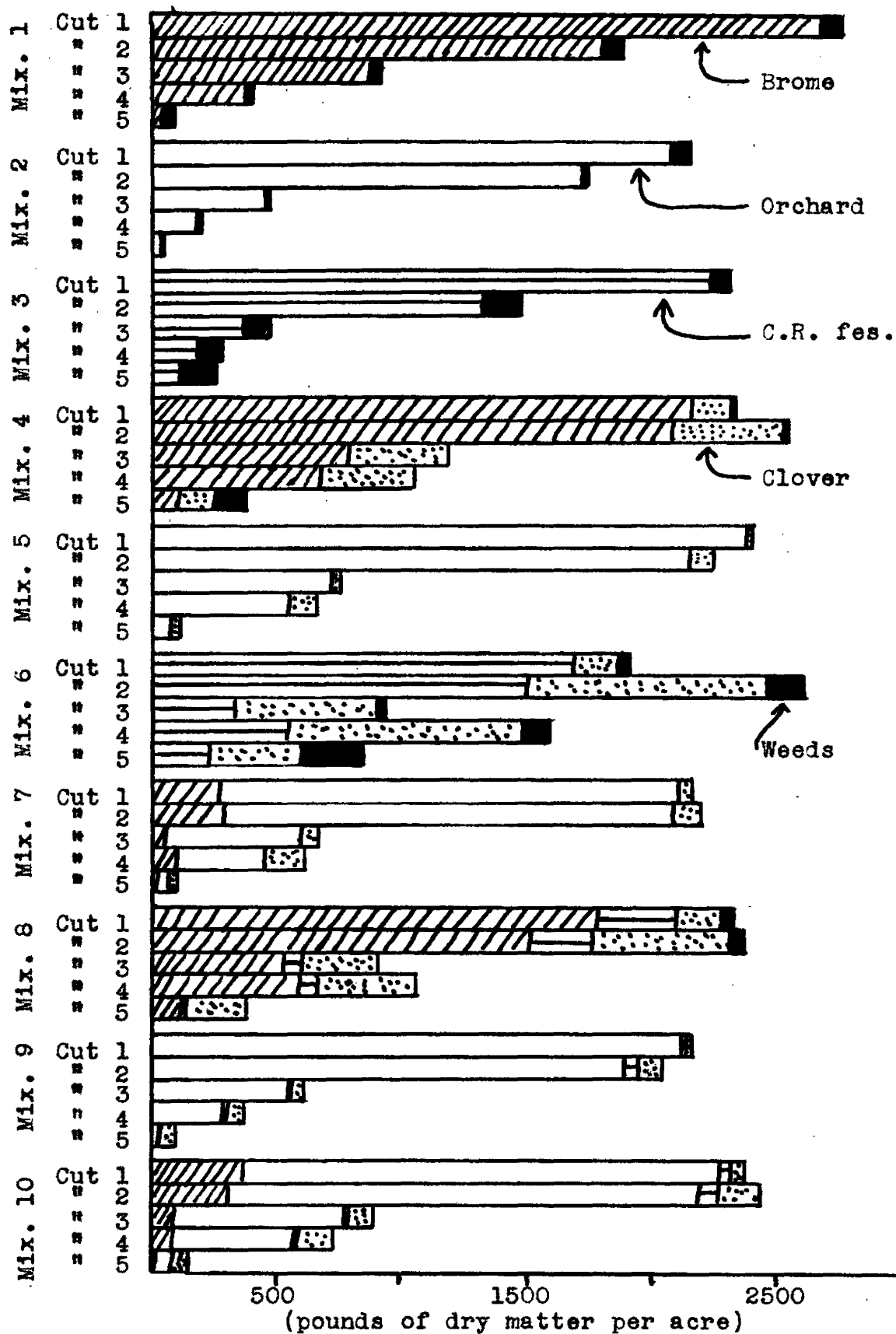


Figure 9. Yield of pastures by components at Lethbridge, 1953

too late to obtain more material, since the separations required several weeks.

Percent protein in bromegrass and orchard grass, in all associations, was significantly greater in cut 1, than in the other 3 cuttings for which determinations were made. However, the different associations had no significant effect on protein content of these grasses. Protein content of bromegrass in the different associations is recorded in Table 7. Orchard grass protein content is recorded in Table 8.

Protein content of creeping red fescue under different treatments could not be analyzed statistically for cuts 2 and 3, because too many samples were missing. However, significant differences were found in cut 4. Similarly, clover could not be analyzed for cut 2, but there were significant differences in cuts 3 and 4. Protein contents of fescue and clover for each of 4 cuts are recorded in Tables 9 and 10 respectively. For cuts in which samples were missing, figures are averages of as many replicates as were available.

Table 7. Percent crude protein of smooth brome grass grown in different associations of species at Lethbridge in 1953. (Average of 5 replicates)

Grown with-	Cut 1	Cut 2	Cut 3	Cut 4
Brome	25.8	20.3	17.9	16.6
Clover	25.3	20.7	21.0	19.4
Orchard & Clover	25.9	15.0	18.3	13.7
C.R. fescue & Clover	24.6	19.1	19.6	18.4
Orch., C.R.F., & Cl.	25.8	15.6	19.1	16.1

No significant differences

Table 8. Percent crude protein of orchardgrass grown in different associations of species at Lethbridge in 1953. (Average of 5 replicates)

Grown with-	Cut 1	Cut 2	Cut 3	Cut 4
Orchard	23.6	10.9	12.6	11.8
Clover	23.2	11.7	12.7	13.5
Brome & Clover	24.5	12.6	14.6	14.4
C.R. fescue & Clover	22.6	12.8	13.9	13.2
Brome, C.R.F., & Clov.	24.4	13.6	15.3	14.2

No significant differences

Table 9. Percent crude protein of creeping red fescue grown in different associations of species at Lethbridge in 1953. (Average of replicates)

Grown with-	Cut 1	Cut 2	Cut 3	Cut 4
C.R. fescue	21.7	13.2	12.6	11.0
Clover	22.6	15.4	16.2	15.2
Brome & Clover	21.7	16.7	15.3	14.6
Orchard & Clover	22.0	12.4	11.2	12.4
Brome, Orch., & Clover	22.6	13.8	13.5	12.2
5% least sig. diff	N.S.	—	—	2.2

Table 10. Percent crude protein of white Dutch clover grown in different associations of species at Lethbridge in 1953. (Average of replicates)

Grown with-	Cut 1	Cut 2	Cut 3	Cut 4
Brome	24.7	23.7	22.7	23.5
Orchard	27.4	19.1	19.7	19.1
C.R. fescue	25.0	22.3	23.0	24.2
Brome & Orchard	27.2	20.3	19.8	21.1
Brome & C.R. fescue	25.8	23.0	22.4	22.7
Orchard & C.R. fescue	26.0	20.5	19.1	20.3
Brome, Orch., & C.R.F.	25.4	21.4	20.3	20.8
5% least sig. diff.	N.S.	—	1.7	1.4



## DISCUSSION

There is little doubt that some of the species and mixtures would have reacted differently under a different cutting schedule. Orchard grass was particularly advanced in growth by the time of the first cutting, and had almost eliminated the clover and fescue growing with it. Brome also restricted the growth of these two species, but to a lesser extent. Percentage clover in brome and orchard grass mixtures increased considerably as the season advanced, but its yield was still relatively low. Percentage fescue did not increase appreciably. These relationships can be seen in Table 1.

Data from 1952, not presented here, show that the plants were fairly well established by the end of the first year. Botanical composition of the plots was approximately the same at the end of 1952 as at the beginning of 1953.

The main reason for the rapid decline in growth of the grasses after cut 2, appeared to be nitrogen deficiency. Several factors lend evidence to this supposition. Orchard grass particularly, and brome to some extent, showed characteristic symptoms of nitrogen deficiency. Protein content of all three grasses fell markedly after cut 1, as seen in Tables 7, 8, and 9. This drop is particularly significant in view of the fact that the plants were less mature in cuts

2, 3, and 4, than in cut 1. Clover, which was able to obtain atmospheric nitrogen, increased somewhat in yield as the season advanced, and in general maintained a high protein content. Protein content of fescue in cut 4 was considerably higher when it was grown with clover, than when grown alone.

The rate of nitrogen fertilizer application, 50 pounds of elemental nitrogen per acre, had purposely been light, in order that differences between clover and non-clover mixtures might be shown. The fertilizer was to have supplied nitrogen for the grasses until the clover developed. If the first cutting had been made earlier, as intended, the clover might have developed more. Thus, it could have supplied more nitrogen for the grasses. Several authors have reported such an effect of timely clipping (Sprague and Garber 1950, Kennedy 1950, Eby et al. 1950).

Another possible reason for a nitrogen deficiency is loss through leaching. More than 8 inches of rain fell in the month of June, and since drainage of the soil was good, some nitrogen probably was carried out of the plant root zone.

Following the heavy June rains, unusually hot and dry weather prevailed. This also led to the decline in growth after cut 2. Although the land was irrigated, there were times when the plants suffered from lack of water.

Yields and trends of brome grass can be seen graphically in Figure 1. It is evident that yields fall into two

groups. When grown in mixtures with orchard grass, brome yielded less than when not grown with orchard grass. Seasonal trends also fall into two groups. When clover was a major component of the sward, brome yields declined less rapidly than when clover was not a major component. Therefore, it appears that clover influenced the seasonal trend, but orchard grass did not, except indirectly by restricting the growth of the clover. Creeping red fescue had no significant influence on brome yields or trends.

Orchard grass dominated all other species growing with it, but to different degrees. Brome competed with it to some extent, but creeping red fescue was almost eliminated from mixtures with it. Clover was suppressed almost as much as fescue. Orchard grass comprised 80 to 100 percent of the herbage of all its mixtures. Therefore, it is not surprising that the other species did not significantly influence its yields. The similarity of orchard grass yields in all associations is evident from inspection of Figure 2.

Creeping red fescue proved to be the weakest competitor of the three grasses. It did compete better with brome than with orchard grass, but it still did not contribute much to the yield of the bromegrass mixture. Clover apparently had no adverse effect on the fescue yield, in fact the relationship appeared beneficial. Rate of decline in yield of fescue was reduced in the fescue-clover association, and percent protein was increased. This was undoubtedly due to the nitrogen supplied by the clover.

Percent clover in all mixtures increased over the season. However, the increase in percent of clover was due to a decline in yield of the associated grasses. Actual yields of clover fluctuated about a general average for the season, but did not increase much. Orchard grass was clover's strongest competitor, brome next, and creeping red fescue was the least competitive. This is evidenced by clover yields in Table 5.

Undoubtedly, lack of available nitrogen was an important factor in limiting growth, but there must also have been other factors concerned. Competition between clover and the grasses is not likely to have been for nitrogen, because the clover roots did have nodules. Possibly lack of light reduced the growth of clover in the orchard grass and brome-grass mixtures in the early part of the year. Creeping red fescue, which never grew higher than about 6 inches, did not shade the clover as much. Thus, if light were the most important factor involved, fescue would not be expected to reduce the clover yield as much as the other grasses did. After cut 2, when the shading effect of brome and orchard grass was not great, clover yields did not increase, but they were maintained, while grass yields declined. Shading by brome and orchard grass could also partially explain why creeping red fescue grew so poorly with them. However, fescue yields continued to decline after cut 2, when shading was no longer great. Thus, low light intensity could have been a limiting factor to clover and fescue in the early part of the

season, but other factors must have been limiting in the latter part.

Dominance of orchard grass over brome grass is not reasonably explained by competition for light, although the quick recovery of orchard grass from clipping might give it some advantage. Orchard grass might have competed more strongly than brome grass for nitrogen. This is suggested by the data of Table 7. Although differences were not statistically significant, protein content of brome grass in cuts 2 and 4 appeared to be lower when orchard grass was in the mixture, than when it was not. This was not a reflection of the amount of clover in the mixture, for even when brome was grown without clover its protein content appeared to be higher than when it was grown with orchard grass and clover. Rather, the protein content of brome grass seemed to be dependent on the amount of orchard grass in the mixture.

Competition between brome and orchard grass could have been for some element required in protein metabolism other than nitrogen. This suggestion is supported by the fact that the protein content of clover was lower in all mixtures containing orchard grass than in non-orchard grass mixtures. The reduction was in proportion to the amount of orchard grass in the mixture. Brome reduced the protein content of clover less than orchard grass did, but more than creeping red fescue did. As previously stated, it is unlikely that competition between grasses and clover was for nitrogen.

Creeping red fescue and brome grass competed with

orchard grass, and reduced its yield to some extent. One result of the reduction in orchard grass, was an increase in clover in the mixture. The orchard grass appeared to benefit from the clover through increased protein content, and a reduction in the rate of decline of yield, although the differences were not significant. The brome and fescue did not benefit from the clover in the orchard grass mixtures. Similarly, fescue was effective in reducing the growth of brome somewhat, in the brome-fescue-clover association, with a consequent increase in clover. The brome benefited from the increased clover through a reduction in the rate of decline of yield, but the fescue did not benefit. Perhaps this indicates that fescue could compete successfully with brome for some factor which only partially limited growth, but it was unable to compete for nitrogen. A similar relationship could exist between brome and orchard, and fescue and orchard.

Creeping red fescue grown alone, yielded as much over the season as either of the other grasses grown alone. However, it permitted more clover to grow than the other two grasses did. Disregarding light temporarily, it seems possible that the factor that limited growth of the clover was used in smaller quantities by the fescue than by the other two grasses. Similarly, brome did not limit clover as much as did orchard grass, possibly because it used less of the factor limiting the growth of clover. The amount of such a factor, or several different factors, used by the different

species could also explain the dominance of orchard grass over brome, and of both grasses over fescue and clover. There is little doubt that light was also an important factor in the growth of fescue and clover.

Thus, it appears that many factors may have limited growth. Any one species may have been able to compete more successfully for one factor than another. Growth of each species in a mixture would depend, then, on the importance of the factor for which it was unable to compete. Whatever the nature of the competition, it did exist, and through it, one species was able to influence the growth of another. The effect of clover could be considered beneficial only. It reduced the rate of decline in yield of the grasses, and increased the protein content, without reducing the total yield. The influence of the grasses on each other was not beneficial.

Total yields of mixtures, recorded in Table 6, indicate the value of clover. All mixtures of which clover was a major constituent, yielded more, and had more uniform seasonal production, than non-clover or low-clover mixtures. A study of the tables indicates that clover helped to give more uniform production by two means. First, by supplying nitrogen for the grasses, and secondly, by filling in the gap left by the slow growth of the grasses. This is in agreement with the statement of Mulder (1952), referred to earlier. Including more than one grass in a mixture had no advantage in either yield or production trend.

Creeping red fescue might be regarded as a less valuable grass than the other two, because of its poor competitive ability. However, when it was grown with clover, the mixture yielded as much as, or more than, any other mixture. This emphasizes the need to test a species under several conditions, in order to evaluate it properly. Creeping red fescue may have another place in a pasture mixture, in that it helps to form a firm sod.

The contribution of each species to the mixtures can be seen graphically in Figure 9. The dominance of orchard grass is strikingly evident. The "weeds" consisted almost entirely of species used in the test. They were weeds, only in the sense that they occurred in plots in which they were not intentionally sown. Since they were useful species, they were included in the total yields of the mixtures.

These results lend evidence to support the view that there is no inherent advantage of mixtures over single species, as far as yields are concerned. Clover increased the yield of grasses, and made seasonal production more uniform, but that was chiefly because it could obtain atmospheric nitrogen. If fertilizer nitrogen had been adequate, clover might not have influenced yields. However, clover must be regarded as an important source of nitrogen for the sake of economy.

Many recommendations for pasture have been based on the premise that the more diverse the characteristics of the component species, the better they will grow in association.



Such a premise is not justified on the basis of these results. The species used in this experiment have different root systems, different water requirements, respond differently to time of season, and grow to different heights. They undoubtedly differ in other ways also. However, these differences could not compensate for limitations in growth factors. The influence of one species on another, was such that none could fully express its individual characteristics.

It is probably possible to obtain more uniform seasonal production by taking advantage of the different periods of growth of pasture species. However, in order to do this, it will be necessary to grow each species free from excessive competition. In a mixture, if grasses were alike in aggressiveness, and ability to compete for all growth factors, they should maintain approximately equal proportions. Then, each should be in a position to respond to the time of season to which it is best adapted. An alternative, is to grow several combinations of one grass and one legume, and graze each mixture in rotation. The importance of proper fertilizing should not be overlooked.

Investigations such as the one here described can establish the relative competitive ability of pasture species. The bases for the competition should be determined by analysis of all the growth factors. Chemical analyses of soil, and of plant material, should be particularly valuable. Rates of seeding of each component will undoubtedly

influence the results. Seeding rates used in this experiment were sufficient to give good stands on all plots, but did not appear to be too heavy. If orchard grass had occupied a smaller proportion of the seeds mixture, it might not have appeared to be so aggressive. However, the relative aggressiveness of the grasses was established with the seeding rates used.

## SUMMARY

Plots were established in 1952, on irrigated land, at the Dominion Experimental Station, Lethbridge, Alberta, Canada.

Three grass species, smooth brome grass (Bromus inermis Leyss), orchard grass (Dactylis glomerata L), and creeping red fescue (Festuca rubra L) were grown alone, and in all combinations with each other and with white Dutch clover (Trifolium repens L). Seasonal growth trends and yields of each species, alone and in associations, were compared, for 5 clipping harvests in 1953. Total yields of mixtures were also compared, and the contribution of each species was considered. Percent protein of the separated species was determined.

Orchard grass was the strongest competitor of the grasses, brome grass was next, and creeping red fescue was the weakest. Lack of nitrogen is considered to be the factor that was most limiting to growth of the grasses, although other factors may have been important also.

Clover comprised a major part of the fescue-clover association, a lesser part of the brome-clover association, and almost no part of the orchard-clover association. Clover increased the protein content of the grasses, and helped to maintain yields over the season, in proportion to its

amount in the sward. Thus, in association with clover only, creeping red fescue benefited considerably, brome to some extent, and orchard very little. In the brome-fescue association, only brome benefited from the clover, since it was the strongest competitor. There was very little benefit from clover in any of the orchard grass associations.

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